Research Article ISSN 2690-537X

Dermatology Research

A Comparative Study of Serum Zinc Levels in Melasma Patients and Control: A Case-Control Study

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Received: 01 Aug 2025; **Accepted:** 04 Sep 2025; **Published:** 14 Sep 2025

Citation: Rini Thukral, Sudhir Singh, Bhushan Madke. Melanyc: A Comparative Study of Serum Zinc Levels in Melasma Patients and Control: A Case-Control Study. Dermatol Res. 2025; 7(2): 1-7.

ABSTRACT

Background: *People of Asian, African, and Latino ancestry are commonly disproportionately affected by the skin disorder melasma. Melasma is characterised by a darkening of sun-exposed facial skin, most noticeably the cheeks, forehead, and nose areas. It was hypothesised that UV light encourages keratinocytes to produce more plasmin activity. The peak age for onset is estimated to be between 30 and 44 years. While women are disproportionately affected by melasma, men are not immune. Fitzpatrick skin phototypes III- IV have been found to be the most common in Melasma patients.*

Aims & Objective: *To access is there any relation between melasma and serum zinc levels.*

1. *Figuring out the average blood zinc levels in melasma patients.*
2. *Are there any link between low zinc levels in the blood and melasma.*

Materials and Method: *An observational case-control study was conducted. A sample size of 132 patients having complaints of melasma and other skin diseases as control were selected. Patients were enrolled at AVBRH sawangi dermatology outpatient department wardha, India. Following patient consent, blood samples were collected and sent to the laboratory for further analysis. This is done to compare serum zinc levels between melasma and other skin disease patients in adulthood.*

Results: *The baseline characteristics have been presented for the recruited patients shows the age distribution of the study participants. With mean age of patients was 38.53yrs in cases and 35.35yrs in control group with no significant mean difference. The mean level of serum zinc in cases (78.23±27.79) was found to be significantly lower compared to controls (104.91±45.57). ($p<0.01$).*

Limitations: *It was not a population-based study, rather a hospital-based study. Moreover, patient could not be followed up on long term basis. Serum Zinc Level test expense, due to which moderate number of patients can be taken up in the particular study. Small sample size of the study. Patients in whom the zinc levels were reduced, they were not managed by giving any Zinc supplements.*

Conclusion: *Based on the findings, the study shows some substantial link between levels of serum zinc in affected patients of melasma. When compared to controls, melasma patients had lower serum zinc levels. Deficiency of zinc may influence melasma pathogenesis. The study does, however, strengthen the recommendation for testing for zinc deficiency in melasma patients. And the serum zinc levels findings should be interpreted with caution because the differences in mean scores were statistically significant.*

Keywords

Melasma, Serum zinc, Evaluation, Pigmentary disorder, Deficiency, Skin phototype.

Introduction

Melasma is a frequent pigmentary condition in the Asian population. It is often referred to as the pregnancy mask or chloasma. People

of Asian, African, and Hispanic descent are disproportionately affected by the skin disorder melasma [1-3].

Melasma is a hyperpigmentation of the sun-exposed face, particularly the cheeks, forehead, and nose regions, that appears as symmetrical macules and patches that range in colour from light to grey-brown and have irregular, jagged, and geographically determined borders [4]. The exact process is unclear, although it has been proposed that ultraviolet (UV) light stimulates plasmin activity in keratinocytes, which then raises melanocyte-stimulating mediators such arachidonic acid and melanocyte-stimulating hormones. Keratinocytes respond immediately to UV light. ultraviolet radiation can damage cell membrane by triggering lipid peroxidation, producing free radicals that in turn may stimulate melanocytes to overproduce melanin. Pregnancy, changes in uterine or ovarian hormones, oral contraceptives, thyroid disease, are all common causes of melasma. The idea that physiologically active melanocytes are the cause of melasma is supported by an increase in vascularization in the affected skin and a high expression of angiogenic factors in the epidermis. Traditionally, topical hydroquinone-based treatment and strict light protection have been the main pillars of treating melasma.

Additional complementary treatments include chemical peels, and laser treatments, all of which have limited variable response. There have been several studies of serum zinc in skin conditions. Melasma has been shown to have a detrimental and mentally damaging effect on quality of life, according to several studies. Recent research indicated that 65% of patients were uncomfortable with it either constantly or often. Furthermore, 57% expressed humiliation, 55 % expressed annoyance, and 42 % stated that melasma had an impact on interpersonal interactions [5]. Melasma is classified based on its location as well as its depth of involvement. The three subtypes of melasma are the centrofacial, malar, and mandibular, all of which are dependent on the distribution of the pigment on the face. Wood's lamp illumination is often used to evaluate the depth of melasma, allowing for further classification into epidermal, dermal, mixed, and ambiguous kinds. However, this diagnosis does not always agree with histology.

Epidermal melasma is commonly confused with dermal melasma. The facial involvement and treatment challenge of melasma [6] have a disproportionately large influence on patients' quality of life. Regardless of the fact that there are several potential triggers for hyperpigmentation. The tyrosinase-related proteins (TRPs) TRP-1 and TRP-2 also play important roles in pigmentation disorders [7]. Tyrosinase is a crucial enzyme in melanogenesis. Overproduction of pigment occurs in melasma because of a disruption in the homeostatic systems that normally regulate skin colour.Topical medicines and chemical peels are two examples of conventional treatments. Patients with melasma often go to nontraditional therapies like laser and light therapy since the condition is difficult to manage. Treatment options for melasma have been discussed [8], including the use of lasers and other forms of light therapy. The most frequently used lasers and light treatments in use today are intense pulsed light, low fluence Q- switched lasers, and nonablative fractionated lasers [9,10]. The majority of them (nine out of ten) seem to be effective, but they often reoccur over time, and some of them are associated with a higher risk of post-inflammatory hyper- or hypopigmentation [11,12].

The goal of this research is to determine if melasma is related to zinc deficiency. It's no exaggeration to say that people in both the industrialised and developing nations are suffering from zinc deficiency. The incidence of zinc insufficiency can be seen anywhere from (11.3 percent to 80 percent). An estimated 74.3% of the population in Indonesia has a zinc deficiency. Zinc is an antioxidant and anti-inflammatory agent that can be used to regenerate damaged skin. Zinc is also necessary for the endocrine system. There is a lot of complexity to its involvement in keeping a healthy thyroid homeostasis and thyroid function [13-15]. Thyroid hormone secretion relies on the mineral zinc, which is essential for the normal functioning of many other organs as well. The majority of the literature agrees that measuring zinc levels in serum is useful. This study used the atomic absorption spectrophotometry (AAS) method because it is simple, sensitive, accurate, and fast [16-18].

Materials and Methods

Place of Study

AVBRH Sawangi (Meghe)Wardha, Out Patient Dermatology Department.

Data Collection Timeline

The research lasted one and a half years, from December 2020 to April 2022.

Study Design

Case- Control Study.

Study Setting

This research will include melasma patients over the age of 20 who go to the AVBRH Outpatient Department of Dermatology, Venereology, and Leprosy at the Jawaharlal Nehru Medical College in Sawangi, Wardha between December 2020 and April 2022.

Sample Size

Formula for sample size with acceptable margin of error: $n = \frac{[Z\alpha/2.^2 P (1-P)}{d^2}$

Where:

Zα/2 = the level of significance at 5% (i.e. 95% confidence interval=1.96) P = Prevalence of melasma in pregnancy =15.8% =0.158

d = Desired error of margin =7% =0.07

$n = \frac{(1.96)^2 x\ 0.158x(1-0.158)}{(0.07)^2}$

= 78

~ n = 78 patients

Formula Reference: Dr. Sanjay Zodpey et al., workshop on sample size consideration in medical research, August 20-22, 1999.

Study Population

After informed consent of 132 patients with age more than 20 years, having melasma were chosen, with 78 cases and 54 controls attending AVBRH outpatient department of Dermatology, Venereology, and Leprosy at (Sawangi) wardha.

Inclusion Criteria

1. Patients with melasma.
2. Patients willing to participate.
3. Patients with age >20 years female patients.
4. Pregnancy, lactation, if patient on any hormonal contraceptives.

Exclusion Criteria

1. Hydroquinone or tranexamic acid use throughout the research or during the previous three months.
2. Endocrinological disease.
3. Hormone alternative therapy.
4. The private or family track record of one of the following: Diseases of the immune system, blood clotting, the circulatory system, the retina, and the kidneys all contribute to a wide range of symptoms and health risks.

Methodology

Melasma patients over the age of 20 who were enrolled in between December 2020 and April 2022.The permission of the Institutional Ethics Committee will be sought. Patients who volunteered to take part in the trial all gave their informed consent in writing. Demographic information (age, gender, socioeconomic status, employment, marital status, occupation, precipitating factors, period of melasma, previous treatments, and skin phenotype, type of melasma, and affected areas) Epidemiological data was gathered from medical records. Epidermal, dermal, and mixed melasma types were distinguished using Wood's light. The ability to distinguish between epidermal and dermal lesions using Wood's lamp depends on whether the lesions become worse or get better when exposed to light.

Preperation Method

Each case and control received a 5ml intravenous blood sample, and the serum supernatant was separated by centrifugation for 10 minutes at 1700gm before being frozen at -40°C for further investigation. Using zinc-free plastic syringes, blood samples were drawn and placed in a zinc-free centrifugation tube. To convert from-degree to serum zinc levels, the atomic absorption spectrophotometry method is used. Zinc deficiency described as serum zinc ranges much less than 70 ug/dl.

Statistical Analysis

All the patient's data were collected in proforma and entered in excel sheet. Mean and standard deviation were used to depict quantitative data, whereas frequency and percentage were used to describe qualitative data. The data was aggregated and shown in several formats including tables, figures, a bar chart, and a pie chart. In order to do the statistical analysis, we use both descriptive and inferential statistics from the social sciences statistical package. The Chi-square test and z-test for difference in means were run in SPSS 27.0 and GraphPad Prism 7.0, and the level of significance was set at 0.05 for both.

Ethical Consideration

"Institutional review board approval was obtained prior to research initiation to ensure compliance with all applicable ethical principles."

"All study participants provided written informed consent."

"At all stages, confidentiality and privacy were maintained."

Results

The baseline characteristics have been presented in (Table 1) for the recruited patients shows the age distribution of the study participants. It was observed that maximum participants were in age group of 31-40yrs (46.15%) then in group 41-50yrs (29.49%) and 20-30yrs (16.67%). Only 6 patients (7.69%) were in the group more than 50 yrs. of age. With mean age of patients was 38.53yrs in cases and 35.35yrs in control group with no significant mean difference. Table 1 shows the age distribution of the study participants. It was observed that maximum participants were in age group of 31-40yrs (46.15%) then in group 41-50yrs (29.49%) and 2030yrs (16.67%). Only 6 patients (7.69%) were in the group more than 50 yrs. of age. With mean age of patients was 38.53yrs in cases and 35.35yrs in control group with no significant mean difference.

The individuals in the case and control groups had significantly different mean ages, as seen in (Table 2). The mean lifespan of cases was 38.53±8.10 years old, whereas the average age of controls was 35.35±12.98 years old (p>0.05).

Table 1: Distribution of the participants according to age. (n=132).

Age (in years)	CASES	% of CASES	CONTROLS	% of CONTROL	Total	Overall percentage
<20 yrs	0	0	5	9.26	5	3.79
20-30 yrs	13	16.67	18	33.33	31	23.48
31-40 yrs	36	46.15	15	27.78	51	38.64
41-50 yrs	23	29.49	7	12.96	30	22.73
More than 50 yrs	6	7.69	9	16.67	15	11.36
Total	78	100	54	100	132	100
Mean± SD	38.53±8.10 (22-61 years)		35.35±12.98 (16-70 years)		37.23±10.45 (16-70 years)	
χ^2-value	19.88, p-value=0.0005, Significant					

Mean age of patients for Melasma cases = 38.62±8.32 years.

Mean age of patients for control group = 33.55±13.08 years.

Table 2: Comparison of the mean age of participants.

	Cases		Controls	
	Mean	SD	Mean	SD
Age	38.53	8.10	35.35	12.98
t- value	1.73,p-value=0.085, Not Significant			

The above-mentioned (Table 2) shows Comparison of the mean age of participants in both cases and control groups. The mean age of participants in cases was 38.53±8.10 years and controls as 35.35±12.98 yrs.(p>0.05).

Among the total 78 patients distribution of pattern of melasma is mentioned in (Table 3) in which Centro-facial type in 53.85% of patients and 46.15% with malar type pattern. Study did not report any mandibular type of clinical pattern of melasma.

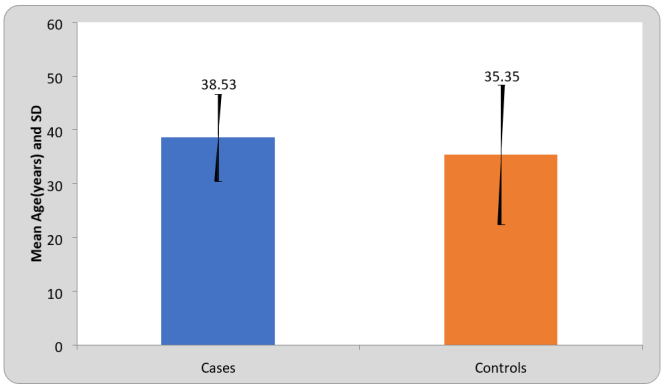

Figure 1: Comparison of Mean age of participants.

Table 3: Number of patients as per the type of melasma.

		Frequency	Percent
Clinical pattern	Centro-Facial	42	53.85
	Malar	36	46.15
	Mandibular	0	0
	Total	78	100.0

The above (Table 3) showing the distribution of the type of melasma among the cases. among total of 78 patients, study detected the Centro-facial type in 53.85% of patients and 46.15% with malar type pattern. Study did not report any mandibular type of clinical pattern of melasma.

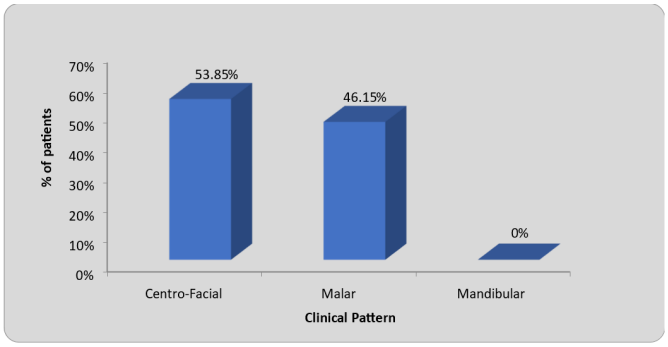

Figure 2: Distribution of participants as per the types of melisma.

Zinc deficiency amongst the cases and control is depicted in (Table 4). There was significant difference between the distributions of the deficiency of zinc level between the groups. In this study, 12 melasma patients and only 3 in the control group had low serum zinc levels.

Table 4: Number of patients with zinc deficiency in cases and control.

	No. of patient in cases	Percentage	No. of Patient in Control	Percentage	ϰ2-value
LEVELS ZINC DEFICIENCY	12	15.38 %	3	5.56%	4.31 P=0.037,S

The above-mentioned (Table 4) showing the presence of zinc deficiency among the cases and control. There was little significant difference between the distributions of the zinc level deficiency between the groups as cases had (15.38%) and control had (5.56 %) respectively.

Zinc levels were compared between the two groups in the mean serum concentration in (Table 5). The mean level of zinc among the cases (78.23±27.79) was found to be significantly lower compared to controls (104.91±45.57). (p<0.01).

Table 5: Mean comparison of the zinc levels between the groups.

	Cases		Controls		z-value
	Mean	SD	Mean	SD	
Zinc level	78.23	27.79	104.91	45.57	4.17 P=0.0001,S

The above-Mentioned (Table 5) shows the mean comparison of the serum Zinc Levels Between the cases and controls. The mean level of zinc among the cases (78.23±27.79) was found to be significantly lower compared to controls (104.91±45.57). (p<0.01).

The mean MASI Score according to the findings is mentioned in (Table 6). The mean MASI score among the cases was found to be 10.49±2.36, with minimum score as 7.20 and maximum score of 16.10. Z-value 1.56, p-value=0.12, Not Significant.

Below-mentioned (Table 6) show the mean level of MASI Score according to the findings. The mean level of MASI score among the cases was found to be 10.34±2.28, with minimum score as 7.20 and maximum score of 7.50 with mean levels of 11.50 ± 3.00 respectively.

Table 6: Showing the mean level of MASI score among the participants and MASI score in patient with zinc deficiency.

	N	Minimum	Maximum	Mean	SD
MASI score	78	7.20	16.10	10.34	2.28
MASI Score in Patients with Zinc Deficiency	12	7.50	16.10	11.50	3.00
z-value	1.56,p-value=0.12, Not Significant				

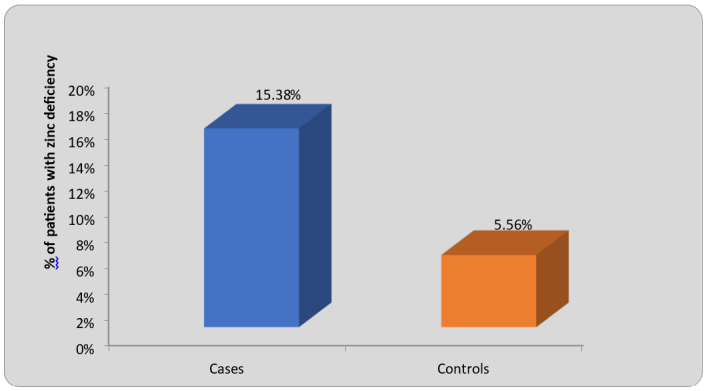

Figure 3: Number of patients with zinc deficiency in cases and control.

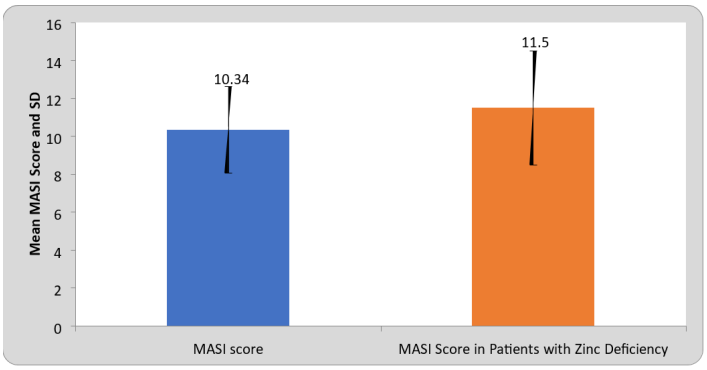

Figure 4: Comparison of mean level of MASI score among the melasma patients and MASI score in patients with zinc deficiency.

Discussion

Melasma or chloasma is a commonly acquired hyper melanosis with preponderance in the female patients of Asian population. Melasma is more common in females with Fitzpatrick skin phototypes IV–VI than in males. With the majority of instances, the sun-exposed parts of the face are covered in macules or patches with uneven, serrated, and geographical borders that range in colour from light to dark brown. Melasma's actual origins are unknown, although several variables have been linked to its pathophysiology, including genetics, sun exposure, hormones in women, pregnancy, birth control pills, anticonvulsants, thyroid problems, and cosmetics [19,20].

The present investigation sought to compare the blood zinc levels of melasma patients to those of healthy controls in order to ascertain whether or not there is a correlation between the two groups. The ultimate conclusion was reached by comparing estimated serum zinc levels in melasma and other skin disorders to those of healthy individuals.

A total of 132 individuals were included in the current research, 78 of whom had melasma and 54 of whom suffered from other skin diseases and served as Controls. The majority of research participants (46.15 percent) were between the ages of 31 and 40, while just six patients (7.5 percent) were older than 50. The average age of a melasma patient was 38.62±8.32 years (cases) and 33.55±13.08 years (controls), a statistically significant difference.

In study by Rambe PS et al., 36.7% of patients were in age group of 46-55, 43.3% in age of 36-45years, 13.3% in 56-65years and 6.7% in 26-35years of age [12]. On assessment of the distribution of the type of melasma, majority were with Centro-facial i.e. (53.7%) whereas Mogaddam et al. found that centrofacial type was prevalent in 72% patients. We found that 46.3 percent of patients had malar melasma, which is higher than the results of Mogaddam et al., who noted that only 3.2 percent of patients had this kind. They also reported that no patient had mandibular pattern which was similar to our study. Additionally, according to Mogaddam et al., 24.6% of patients exhibited both centro-facial and malar distribution [21-25].

On assessment of MASI score the mean score among the cases was found to be 10.30±2.26, with minimum score as 7.20 and maximum score of 16.10. The average zinc content varies considerably across regions. The case and control groups were significantly different. As 12 patients reported in cases with low zinc levels (15.38%) and patients in control were found to be (5.38%) respectively.

Zinc concentrations in the blood were measured and compared between the two groups. The mean level of zinc among the cases (78.23±27.79) was found to be significantly lower compared to controls (104.91±45.57). ($p<0.01$).

In a separate study, Sekarnesia IS et al. compared the serum zinc concentrations of melasma and non-melasma patients. Those without melasma had a mean serum zinc level of 10.29 1.46 mol/l, whereas those with the condition had a level of 10.25±1.89 mol/l ($p= 0.901$) [26,27]. Additionally, neither the melasma nor non-melasma groups with thyroid impairment nor those without thyroid impairment had blood zinc levels that were significantly different from one another. A research by Mogaddam MR, et al. looked at zinc levels in people with melasma. They observed that 45.8 percent of participants with melasma and 23.7 percent of those without the condition had low serum zinc levels. According to Rambe PS et al., the average blood zinc level in individuals with confirmed cases of melasma was 54.31 g/dL, 53.56 g/dL, and 47 g/dL.

No correlation between melasma severity and serum zinc levels was found [27]. The results of this investigation are at odds with those of a previous study by Rostami Mogaddam et al., which indicated that 45.8% of patients with melasma had low blood zinc levels, compared to 23.7% of patients in the control group. As an anti-inflammatory, antioxidant, and anti-peeling agent (not to mention a popular constituent in sunscreens), zinc seems to be useful in treating melisma [28-32].

Limitations

It was not a population-based study, rather a hospital-based study. Patient could not be followed up on long term basis. Serum Zinc Level test expense, due to which moderate number of patients can be taken up in the particular study. At the conducted time period of

study due to COVID era patients used N-95 masks which indirectly reduced the cumulative photo exposure which in turn reduced the incidence of melasma. Patients in whom the zinc levels were reduced, they were not managed by giving any Zinc supplements.

Conclusion

According to the results, melasma may be linked to low zinc levels in the blood. The blood zinc levels of melasma patients were substantially lower than those of normal controls. Zinc deficiency may influence melasma pathogenesis. The study, however, reinforces the recommendation for melasma patients to be tested for zinc deficiency. In the future, studies evaluating the use of zinc supplements in cases of melasma may be conducted.

References

1. Basit H, Godse KV, Al Aboud AM. Melasma. In: StatPearls. StatPearls Publishing. 2021.
2. Handel AC, Miot LDB, Miot HA. Melasma: a clinical and epidemiological review. An Bras Dermatol. 2014; 89: 771-782.
3. Freitag F, Cestari T, Leopoldo L, et al. Effect of melasma on quality of life in a sample of women living in Southern Brazil. J Eur Acad Dermatol Venereol. 2008; 22: 655-662.
4. Kim EH, Kim YC, Lee ES, et al. The vascular characteristics of melasma. J Dermatol Sci. 2007; 46: 111-116.
5. Grimes PE, Yamada N, Bhawan J. Light microscopic, immunohistochemical, and ultrastructural alterations in patients with melasma. Am J Dermatopathol. 2005; 27: 96-101.
6. Trivedi MK, Yang FC, Cho BK. A review of laser and light therapy in melasma. Int J Womens Dermatol. 2017; 3: 11-20.
7. Lee AY. Recent progress in melasma pathogenesis. Pigment Cell Melanoma Res. 2015; 28: 648-660.
8. Sastrini Sekarnesia I, Sitohang IBS, Agustin T, et al. A comparison of serum zinc levels in melasma and non-melasma patients: a preliminary study of thyroid dysfunction. Acta Dermatovenerol Alp Pannonica Adriat. 2020; 29: 59-62.
9. Rodríguez-Arámbula A, Torres-Álvarez B, Cortés-García D, et al. CD4, IL-17, and COX-2 Are Associated with Subclinical Inflammation in Malar Melasma. Am J Dermatopathol. 2015; 37: 761-766.
10. Bak H, Lee HJ, Chang SE, et al. Increased expression of nerve growth factor receptor and neural endopeptidase in the lesional skin of melasma. Dermatol Surg. 2009; 35: 1244-1250.
11. Rajaratnam R, Halpern J, Salim A, et al. Interventions for melasma. Cochrane database Syst Rev. 2010; 7: CD003583.
12. Ogbechie-Godec OA, Elbuluk N. Melasma: an Up-to-Date Comprehensive Review. Dermatol Ther. 2017; 7: 305-318.
13. Rendon MI. Hyperpigmentation Disorders in Hispanic Population in the United States. J Drugs Dermatol. 2019; 18: s112-s114.
14. Passeron T, Genedy R, Salah L, et al. Laser treatment of hyperpigmented lesions: position statement of the European Society of Laser in Dermatology. J Eur Acad Dermatol Venereol. 2019; 33: 987-1005.
15. Zubair R, Lyons AB, Vellaichamy G, et al. What's New in Pigmentary Disorders. Dermatol Clin. 2019; 37: 175-181.
16. Tamega A de A, Miot LDB, Bonfietti C, et al. Clinical patterns and epidemiological characteristics of facial melasma in Brazilian women. J Eur Acad Dermatol Venereol. 2013; 27: 151-156.
17. Ortonne JP, Arellano I, Berneburg M, et al. A global survey of the role of ultraviolet radiation and hormonal influences in the development of melasma. J Eur Acad Dermatol Venereol. 2009; 23: 1254-1262.
18. Hexsel D, Lacerda DA, Cavalcante AS, et al. Epidemiology of melasma in Brazilian patients: a multicenter study. Int J Dermatol. 2014; 53: 440-444.
19. Goandal NF, Rungby J, Karmisholt KE. [The role of sex hormones in the pathogenesis of melasma]. Ugeskr Laeger. 2022; 184: V10210769.
20. Hernando B, Ibarrola-Villava M, Fernandez LP, et al. Sex-specific genetic effects associated with pigmentation, sensitivity to sunlight, and melanoma in a population of Spanish origin. Biol Sex Differ. 2016; 7: 17.
21. Rostami Mogaddam M, Safavi Ardabili N, Iranparvar Alamdari M, et al. Evaluation of the serum zinc level in adult patients with melasma: Is there a relationship with serum zinc deficiency and melasma?. J Cosmet Dermatol. 2018; 17: 417-422.
22. Duarte I, Campos Lage AC. Frequency of dermatoses associated with cosmetics. Contact Dermatitis. 2007; 56: 211-213.
23. Damevska K. New aspects of melasma. Serbian J Dermatology Venerol. 2014; 6: 5-18.
24. Kwon SH, Hwang YJ, Lee SK, et al. Heterogeneous Pathology of Melasma and Its Clinical Implications. Int J Mol Sci. 2016; 17: 824.
25. Gupta A, Gover M, Nouri K, et al. The treatment of melasma: A review of clinical trials. J Am Acad Dermatol. 2007; 55: 1048-1065.
26. Cunha MG, Paravic FD, Machado CA. Histological changes of collagen types after different modalities of dermal remodeling treatment: a literature review. Surg Cosmet Dermatol. 2015; 7: 285-292.
27. Jang YH, Lee JY, Kang HY, et al. Oestrogen and progesterone receptor expression in melasma: an immunohistochemical analysis. J Eur Acad Dermatol Venereol. 2010; 24: 1312-1316.
28. Noh TK, Choi SJ, Chung BY, et al. Inflammatory features of melasma lesions in Asian skin. J Dermatol. 2014; 41: 788-794.
29. Park K, Kim I. Pathogenesis of Melasma. In: Melasma and Vitiligo in Brown Skin. 2017; 21-31.
30. Kang HY, Lee JW, Papaccio F, et al. Alterations of the pigmentation system in the aging process. Pigment Cell Melanoma Res. 2021; 34: 800-813.

31. Phansuk K, Vachiramon V, Jurairattanaporn N, et al. Dermal Pathology in Melasma: An Update Review. Clin Cosmet Investig Dermatol. 2022; 15: 11-19.

32. Kapoor R, Dhatwalia SK, Kumar R, et al. Emerging Role of Dermal Compartment in Skin Pigmentation: Comprehensive Review. J Eur Acad Dermatology Venereol. 2020; 34: 2757-2765.